

APPENDIX A

STATEMENT OF WORK Zero Energy Homes (ZEH) Energy Supply Systems Integration (24 April 03)

1.0 BACKGROUND

Buildings use two-thirds of all electrical energy consumed in the United States and are responsible for a considerable portion of U.S. peak electrical demand. Because buildings are typically used for 50–100 years, their inertia has a major impact on future energy-use patterns. Recognizing this enormous impact, the Department of Energy's (DOE) Building Technologies Program has adopted the long-term goal of creating marketable buildings that produce all the energy that they use on an annual basis – Zero Energy Buildings. In support of this goal, Zero Energy Buildings will use solar and other renewable energy generation technologies in combination with energy-efficient building envelopes, appliances and systems to reduce the purchased energy requirements of new buildings.

The Zero Energy Buildings strategy entails transforming the design and construction of new buildings so that they use renewable energy and energy-efficiency technologies at levels consistent with building functionality, market needs, and societal concerns. The Zero Energy Buildings concept is designed to catalyze a process that begins with the integration of both energy efficiency and renewable energy generation technologies into new construction. The process will then evolve to the construction of buildings that so successfully integrate efficiency and renewable energy generation that they have a zero-net need for off-site energy on an annual basis. The ultimate market for the Zero Energy Buildings concept is all residential and commercial building construction in the U.S. However, this Statement of Work (SOW) is focused on residential buildings (with potential application to small commercial buildings) and is specifically aimed at single-family homes, hereafter generically referred to as *Zero Energy Homes*.

Over the last two years, DOE's Zero Energy Homes efforts have identified the need for construction products that integrate solar electric and solar thermal technologies into standard building components (e.g., roofing materials) rather than being installed on top of or in addition to the conventional building materials. Therefore, DOE and NREL are interested in awarding phased subcontracts to industry and/or university teams for research and development of building components that are integrated with solar and other renewable energy generation technologies. At the end of the subcontract's first phase, DOE/NREL will evaluate the concepts developed by the awardees as well as their overall development progress. After this first phase evaluation, DOE/NREL will reduce the number of subcontractors to those working on technologies demonstrating the most promise of meeting the Zero Energy Homes Energy Supply Systems Integration project's goals and objectives. Depending on the stage of development for each proposed concept, this "down selection" may also repeat in future years.

2.0 OBJECTIVE

The ultimate goal of the Zero Energy Homes Energy Supply Systems Integration project is to develop the “next generation” of advanced building products (e.g., roofing materials) that can generate 100% of the electric needs, 100% of the water heating needs, and 100% of the space conditioning needs of a Zero Energy Home. Of course, this Zero Energy Home (ZEH) must reduce traditional energy use by 50 – 70% compared to the typical U.S. house today.

A primary objective of this project – organized into Phases – is to begin development of ***residential building-integrated products that incorporate the onsite generation of solar electric and solar thermal energy – products on the path to producing 100% of the ZEH’s electric needs, 100% of its hot water needs and 100% of its space conditioning needs.*** This “next generation” of onsite renewable energy generation products must also be developed in cooperation with the U.S. construction industry, in order that they can be marketed successfully to the new-home construction market. For the purposes of this solicitation, these types of products are called ***“Zero Energy Home (ZEH) Integrated Energy Supply Systems”***.

The project is organized into four sequential phases (see Section 3.0 below). ***NREL is providing offerors the flexibility to propose a project that can begin with any of the four phases.*** It is expected that most offerors might propose a project that would start with Phase I, followed by Phase II, then Phase III and, finally, Phase IV. However, an offeror can also propose a project that starts with Phase II and goes to Phase III and then Phase IV. Similarly, an offeror can propose a project that starts with a Phase III and is followed by Phase IV or an offeror can simply propose a Phase IV project.

The work specified herein for Phases other than the starting phase selected by the offeror is provided for proposal preparation purposes only. A final deliverable for each Phase will be the necessary price and technical proposal for the next sequential Phase. Based on the merits of the proposal, NREL will determine whether or not to authorize the next phase. In addition, award of future Phases will depend upon: (1) availability of funds; and (2) future needs of the DOE Building Technologies Program.

3.0 SCOPE OF WORK

The project is organized into four phases.

Phase I: Concept Generation / Exploratory Research

- o Activity: Identification and analysis of onsite building-integrated solar and other renewable energy systems that could conceivably be marketed successfully in new residential construction
- o Desired Outcome: Proof-of-concept, development of engineering designs and characterization of potentially marketable building-integrated solar and renewable energy concepts to be developed into prototypes in a Phase II.

Phase II: Concept Development / Prototype Testing

- o Activities: (a) conducting technology development / engineering refinement efforts

relating to the advanced building product concept developed in Phase I (or the advanced building product concept proposed by the offeror in its proposal – a concept for which the equivalent of the Phase I work had already been completed and was determined to be acceptable by DOE/NREL); and (b) constructing and evaluating prototypes
o Desired Outcome: Fully characterized prototype ZEH integrated energy supply system having the potential to result in a marketable product and to be further developed in Phase III.

Phase III: Advanced Development / Destructive and Non-Destructive Testing

o Activities: (a) conducting advanced technology development / engineering refinement efforts relating to the advanced building product concept resulting from the authorization of Phase II (or the advanced building product concept proposed by the offeror in its proposal – a concept for which the equivalent of the Phases I and II work had already been completed and was determined to be acceptable by DOE/NREL); and (b) fabricating and testing (destructive and non-destructive) pre-production versions of the system
o Desired Outcome: Fully characterized and tested pre-production ZEH integrated energy supply system having the potential to result in a cost-effective, marketable product with additional engineering development and product development in Phase IV.

Phase IV: Product Engineering / Field Testing / Manufacturing Process Design

o Activities: (a) conducting final technology development / engineering refinement efforts relating to the advanced building product concept resulting from Phase III (or the advanced building product concept proposed by the offeror in its proposal – a concept for which the equivalent of the Phases I, II and III work had already been completed and was determined to be acceptable by DOE/NREL); (b) fabricating and field testing of close-to-production versions of the system; and (c) development of manufacturing processes
o Desired Outcomes: (a) fully characterized and fully field-tested close-to-production ZEH integrated energy supply system that can be initially tested in the marketplace (e.g., model homes) to determine acceptance to homebuilders and homebuyers; (b) development of the manufacturing processes for manufacturing the ZEH integrated energy supply system in mass production.

In most cases, the subcontractor will begin the project with a Phase I subcontract and take the concept sequentially through Phases II, III and IV.

However, the solicitation is structured so that an offeror can start with a Phase other than Phase I (for example, Phase II) and take the concept sequentially through the remainder of the Phases if authorized by NREL. This provides the subcontractor with the opportunity to exploit the results from R&D that it is currently conducting or has completed related to ZEH integrated energy supply systems. However, in order to start the project at a Phase other than Phase I, the offeror has to demonstrate to NREL that it has met all of the technology development, analysis, testing and evaluation requirements associated with all bypassed Phases. In addition, the offeror must demonstrate that its advanced building product concept meets the objective of this project – to develop residential building-integrated renewable energy generation products on the path to producing 100% of the electric needs, 100% of the hot water needs and 100% of the space conditioning needs of a Zero Energy Home.

Consequently, with adequate supporting documentation, NREL will accept proposals for advanced building product concepts in any of the four stages of development:

3.1 Phase I Statement of Work: Concept Generation / Exploratory Research

The objectives of Phase I are to demonstrate “proof-of-concept”, develop engineering designs and characterize promising, potentially marketable ZEH building-integrated energy supply system concepts (concepts that include solar and other renewable energy technologies) to be developed into prototypes and evaluated in a Phase II.

The subcontractor shall perform the following tasks:

Task (1): Concept Generation

The subcontractor shall identify and analyze onsite solar or other renewable energy system configuration(s) that would supply all or a major portion of a Zero Energy Home’s energy supply. The advanced building product would eventually be marketed as a residential and small commercial building product. Examples include:

- Solar thermal and solar electric systems that are integrated with or replace conventional residential roofing materials, e.g., concrete tiles, asphalt shingles, standing seam metal roofs.
- Solar thermal and solar electric systems that are integrated with new roofing materials such as polymer-based roofs.
- Building-integrated solar thermal and solar electric systems combined with heating, ventilating, and air-conditioning (HVAC) systems, e.g., solar thermal systems that provide source energy to heat pumps (with necessary thermal storage).
- Using the building roof itself as a solar electric and thermal system, while retaining the roof’s structural, insulating, and weathering functions.

Task (2): Exploratory Research

The subcontractor shall conduct exploratory research and demonstrate “proof-of-concept” for its chosen system configuration and submit that analysis to a review panel for evaluation. The “proof-of-concept” analysis should, at a minimum, include technical performance and cost estimates for manufacturing and installing the advanced building product concept.

Task (3): Proposed Phase II Work Plan

Based on the results from Tasks (1) and (2), the subcontractor shall make the decision whether or not they would like to take the concept to Phase II development. If so, the subcontractor shall make the recommendation to DOE/NREL to continue. This shall be done by generating a proposed work plan for a Phase II project that includes the statement of work, schedule, milestones, deliverables and budget (including subcontractor price participation). If the subcontractor chooses to terminate the project at the completion of Phase I, they shall generate a report articulating the reasons and rationale for not continuing. In addition, the report shall include recommendations regarding R&D that the Program might conduct to improve the potential technical and economic viability and marketability of the concept.

The Phase I deliverables shall be as follows:

- (1) Monthly Progress Report (1–3 pages) that covers
 - (a) Major accomplishments and their significance
 - (b) Major success stories that should be brought to the attention of DOE
 - (c) Problems encountered (if any) and how they were resolved
 - (d) Important contacts (if any)
 - (e) Plans for next month
- (2) 75% Design Review/Technical Briefing at DOE in Washington, DC or NREL (complete with handouts)
(three months after execution)
- (3) 100% Design Review and Briefing at DOE to present proposed Phase II project (including proposed Phase II project work plan, milestones, schedules, deliverables, total cost and price participation)
(five months after execution)
- (4) Final report covering: (a) engineering description of the system concept; (b) expected technical and economic performances of the concept; (c) rough estimate of the likely cost of the system; (d) proposed work plan for a Phase II, including the statement of work, milestones, schedule, deliverables, total cost and price participation.
(seven months after execution)

One hardcopy of each deliverable shall be sent to:

NREL Subcontract Administrator
National Renewable Energy Laboratory (NREL)
Building 27, MS 2713
1617 Cole Boulevard
Golden, CO 80401

Two hardcopies, as well as an electronic copy, shall be sent to:

NREL Technical Monitor
National Renewable Energy Laboratory (NREL)
Building 27, MS 2714
1617 Cole Boulevard
Golden, CO 80401

3.2 Phase II Statement of Work: Concept Development / Prototype Testing

The objectives of Phase II are: (a) conducting technology development / engineering improvement efforts to develop a prototype ZEH integrated energy supply system that incorporates renewable energy technology; and (b) fabricating, testing and evaluating the prototype system with respect to its technical and economic performance capabilities and its potential marketability.

In order for a ZEH integrated energy supply system concept to be investigated in a Phase II, the subcontractor must have met either of two requirements: (a) successfully completed Phase I and was selected by DOE/NREL for a Phase II authorization; or (b) was awarded a subcontract by NREL in which the initial project was a Phase II work effort.

The subcontractor shall perform the following tasks:

Task (1): Technology Development / Engineering Design

The subcontractor shall develop detailed designs for their concepts and analyze those designs. Examples of Phase II analysis activities include analytical or numerical (finite element analysis) techniques for structural analysis, heat transfer modeling, and electrical system analysis. The analysis shall also include refined technical performance and cost estimates for manufacturing and installing the advanced building product concept. This activity shall also include any required technology development / engineering refinement efforts.

Task (2): Prototype Fabrication, Testing and Evaluation

The subcontractor shall fabricate prototypes for laboratory-scale testing and building code compliance review. The results of the prototype testing and design reviews will be submitted to an evaluation panel for Phase II review.

Task (3): Proposed Phase III Work Plan

Base on the results from Tasks (1) and (2), the subcontractor shall decide whether or not to take the concept to Phase III development. If so, the subcontractor shall make the recommendation to DOE/NREL and generate a proposed work plan for a Phase III project that includes the statement of work, schedule, milestones, deliverables and budget (including subcontractor price participation). If the subcontractor chooses to terminate the project at the completion of Phase II, they shall generate a report articulating the reasons and rationale for not continuing. In addition, the report shall include recommendations regarding R&D that the Program might conduct to improve the potential technical and economic viability and marketability of the concept.

The Phase II deliverables shall be as follows:

- (1) Monthly Progress Report (1–3 pages) that covers
 - (a) Major accomplishments and their significance
 - (b) Major success stories that should be brought to the attention of DOE
 - (c) Problems encountered (if any) and how they were resolved
 - (d) Important contacts (if any)

- (e) Plans for next month
- (2) 50% Design Review/Technical Briefing at DOE in Washington, DC or NREL (complete with handouts)
(three months after execution)
- (3) 100% Design Review and Briefing at DOE to present proposed Phase III project (including proposed Phase III project work plan, milestones, schedules, deliverables, total cost and price participation)
(up to seven months after execution)
- (4) Final report covering: (a) engineering description of the system concept; (b) expected technical and economic performances of the concept; (c) rough estimate of the likely cost of the system; (d) proposed work plan for a Phase III, including the statement of work, milestones, schedule, deliverables, total cost and price participation.
(up to nine months after execution)

One hardcopy of each deliverable shall be sent to:

NREL Subcontract Administrator
National Renewable Energy Laboratory (NREL)
Building 27, MS 2713
1617 Cole Boulevard
Golden, CO 80401

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National Renewable Energy Laboratory (NREL)
Building 27, MS 2714
1617 Cole Boulevard
Golden, CO 80401

3.3 Phase III Statement of Work: Advanced Development / Destructive and Non-Destructive Testing

The objectives of Phase III are: (a) conducting technology development / engineering improvement efforts to develop a second-generation prototype ZEH integrated energy supply system that incorporates renewable energy technology; and (b) fabricating, testing and evaluating the prototype system with respect to its technical and economic performance capabilities and its potential marketability.

In order for a ZEH integrated energy supply system concept to be investigated in a Phase III, the subcontractor must have met either of two requirements: (a) successfully completed Phase II and was selected by DOE/NREL for a Phase III; or (b) was awarded a subcontract by

NREL in which the initial project was a Phase III work effort.

The subcontractor shall perform the following tasks:

Task (1): Advanced Development / Engineering Design

The subcontractor shall conduct technology development efforts and perform any required design refinement work for the ZEH integrated energy supply system concept based on the results of the Phase II (or equivalent) testing and evaluation. This work shall be designated as the development of the second-generation prototype.

Task (2): Second-Generation Prototype Fabrication and Destructive / Non-Destructive Testing

After completing design refinements, the subcontractor shall fabricate at least five second-generation prototypes and conduct laboratory destructive and non-destructive testing, limited field-testing and evaluation. Examples of Phase III destructive / non-destructive testing activities include accelerated exposure testing, impact testing, and wind load testing. The results of the testing will be submitted to an evaluation panel for Phase III review.

Task (3): Proposed Phase IV Work Plan

Base on the results from Tasks (1) and (2), the subcontractor shall make the decision regarding to whether or not to take the concept to Phase IV development. If so, the subcontractor shall make the recommendation to DOE/NREL by generating a proposed work plan for a Phase IV project that includes the statement of work, schedule, milestones, deliverables and budget (including subcontractor price participation). If the subcontractor chooses to terminate the project at the completion of Phase III, they shall generate a report articulating the reasons and rationale for not continuing. In addition, the report shall include recommendations regarding R&D that the Program might conduct to improve the potential technical and economic viability and marketability of the concept.

The Phase III deliverables shall be as follows:

(1) Monthly Progress Report (1–3 pages) that covers

- (a) Major accomplishments and their significance
- (b) Major success stories that should be brought to the attention of DOE
- (c) Problems encountered (if any) and how they were resolved
- (d) Important contacts (if any)
- (e) Plans for next month

(2) 50% Design Review/Technical Briefing at DOE in Washington, DC or NREL (complete with handouts)

(up to six months after execution)

(3) 100% Design Review and Briefing at DOE to present proposed Phase IV project (including proposed Phase IV project work plan, milestones, schedules, deliverables, total cost and price participation)

(up to ten months after execution)

- (4) Final report covering: (a) engineering description of the system concept; (b) expected technical and economic performances of the concept; (c) refined estimate of the likely cost of the system; (d) proposed work plan for a Phase IV, including the statement of work, milestones, schedule, deliverables, total cost and price participation.
(up to one year after execution)

One hardcopy of each deliverable shall be sent to:

NREL Subcontract Administrator
National Renewable Energy Laboratory (NREL)
Building 27, MS 2713
1617 Cole Boulevard
Golden, CO 80401

Two hardcopies, as well as an electronic copy, shall be sent to:

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National Renewable Energy Laboratory (NREL)
Building 27, MS 2714
1617 Cole Boulevard
Golden, CO 80401

3.4 Phase IV Statement of Work: Product Engineering / Field Testing / Manufacturing Process Design

The objectives of Phase IV are: (a) development of a fully characterized and fully field-tested pre-production version of the ZEH integrated energy supply system -- a system that can be initially tested in the marketplace (e.g., model homes) to determine acceptance to homebuilders and homebuyers; (b) development of the manufacturing processes for manufacturing the system concept in mass production.

Task (1): Final Engineering Refinements

The subcontractor shall conduct and complete technology development and all applicable engineering refinement work (based on the results from the Phase III testing and evaluation) that will result in the design for the pre-production version of the ZEH integrated energy supply system.

Task (2): Fabrication, Testing and Evaluation

The subcontractor shall fabricate, test and evaluate the pre-production system in expanded field-testing. Based on the field testing results, the subcontractor shall identify the technology development and/or engineering refinement work that will be need to be performed to develop the first production model of the system for the marketplace.

Task (3): Manufacturing Process Development

The subcontractor shall design manufacturing processes for manufacturing the system for initial

limited entry into the marketplace.

Task (4): Next Steps

Based on the results from the Phase IV testing and evaluation, the subcontractor shall formulate recommendations regarding: (a) R&D that should be conducted to increase the reliability and the cost-effectiveness of the system; and (b) the strategy for introducing the system into the marketplace.

The Phase IV deliverables shall be as follows:

- (1) Monthly Progress Report (1–3 pages) that covers
 - (a) Major accomplishments and their significance
 - (b) Major success stories that should be brought to the attention of DOE
 - (c) Problems encountered (if any) and how they were resolved
 - (d) Important contacts (if any)
 - (e) Plans for next month
- (2) 50% Design Review/Technical Briefing at DOE in Washington, DC or NREL (complete with handouts)
(up to six months after execution)
- (3) 100% Design Review and Briefing at DOE to present draft products of Phase IV project (including proposed commercialization strategy and schedule)
(up to ten months after execution)
- (4) Final report covering: (a) engineering description of the system concept; (b) expected technical and economic performances of the concept; (c) final estimate of the cost of the system; (d) proposed commercialization strategy and schedule; (e) lessons learned
(up to one year after execution)

Electronic Reporting Requirements for Subcontract Report Deliverables:

As set forth in Department of Energy Order 241.1A, NREL is required to submit in an electronic format all scientific and technical information, including subcontract report deliverables intended for public distribution, to the DOE Office of Scientific and Technical Information (OSTI). In addition, it is NREL's intention to post subcontract report deliverables containing publicly available information (e.g. non-confidential, non-protected, non-proprietary information) for distribution on the NREL Intranet or the Internet.

The Subcontractor shall provide the final approved version of report deliverables intended for public distribution as specified in the deliverables schedule of this Statement of Work in accordance with the following electronic reporting requirements:

- a. The Subcontractor shall submit all report deliverables intended for public distribution (including status, annual, or final reports) as electronic files, preferably with all graphics and images embedded within the document. The

electronic files shall be submitted along with an accompanying hard (printed) copy(ies) of the report. Limited exceptions allowing some graphics and images to be submitted as hard copies only may be granted on a case-by-case basis. The exceptions process for graphics and images is described in Paragraph E below. It shall be made clear in the deliverable transmittal letter that certain graphics and images are supplied in hard copy only.

- b. All final approved version submissions shall be delivered to NREL on PC or MAC-formatted media (3.5 inch disks, Zip and Jaz cartridges, or CD-ROM). Files of 1 Mb or less can be sent via e-mail to the 1) NREL technical monitor, 2) the NREL Subcontract Administrator or Associate (as specified in the Statement of Work).
- c. The preferred format is a single electronic file that includes all of the text, figures, illustrations, and high-resolution digital photographs (or photographs should be scanned and incorporated in the text). Acceptable file formats are:
 - Microsoft Word (v.6.0 or newer for PC or MAC)
 - WordPerfect (v.6.1 or newer for PC)
 - Microsoft PowerPoint
 - Microsoft Excel
- d. If it is not possible to include all of the graphics and images (figures, illustrations, and photographs) in the same file as the text, NREL will accept the text in one of the above formats and the graphics and images as separate electronic graphic or image files*. The native files for any page layout formats submitted shall be supplied. The following software is supported on both Mac and PC platforms:

• QuarkXPress (.qxd)	• Pagemaker (.pm)
• Photoshop (.psd)	• Illustrator (.ai)
• Freehand (.fh)	• Corel Draw (.cdr)
• Framemaker (.fm)	• Microsoft Publisher(.pub)

The acceptable graphic or image file formats are: .eps, .tif, .gif, .jpg, .wpg, .wmf, .pct, .png, .bmp, .psd, .ai, .fh, .cdr. The preferred resolution for graphics or images is 150 to 300 dpi. Include all fonts that were used in creating the file.

- e. In the rare case that the graphics or images cannot be supplied electronically, either incorporated within the text or as a separate electronic file, original hard copies will be accepted. The Subcontractor shall obtain prior approval from the Subcontract Administrator before submitting graphics or images in hard copies. It shall be made clear in the deliverable transmittal letter that certain graphics and images are supplied in hard copy only.
- f. For all calculations in support of subcontract reports that are conducted in

ASPEN+, an electronic copy of INPUT, REPORT and BACKUP (if Model Manager is used) must be submitted with all reports. Additionally, if costing or sizing calculations are conducted in a spreadsheet [no process calculations (heat and material balances) in spreadsheet format are permitted], a copy of the fully documented MS Excel file shall be supplied. Note that vendor quotes and other non-original material can be supplied in hard copy.

- g. A fully executed release shall be supplied to NREL with all photographs, regardless of whether such photographs are delivered to NREL electronically or in hard copy. Such release shall certify that the National Renewable Energy Laboratory and the United States Government is granted a non-exclusive, paid-up, irrevocable, worldwide license to publish such photographs in any medium or reproduce such photographs or allow others to do so for United States Government purposes.
- h. The Subcontractor may contact NREL Publication Services at (303) 275-3644 with questions regarding technical guidance concerning the submission of subcontract report deliverables as electronic files or exceptions to electronic files for graphics and images.

One hardcopy of each deliverable shall be sent to:

NREL Subcontract Administrator
National Renewable Energy Laboratory (NREL)
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Golden, CO 80401

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